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The Rise of Zombie Firms and the Slow Recovery of the Portuguese Economy

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With the guidance of

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I am grateful for each and every one of you!

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Resumo

A desaceleração do crescimento económico dos países desenvolvidos, a última crise financeira e a lenta recuperação económica geraram muita polémica, uma vez que a população é gradualmente mais instruída e as inovações tecnológicas são cada vez mais rápidas.

Assim, o estudo das empresas zombie e o seu impacto na economia portuguesa é extremamente importante devido ao vínculo entre esses três problemas principais. Este trabalho pretende determinar as principais causas do aparecimento, fixação e aumento deste tipo de empresas em Portugal; a sua evolução e importância na estrutura empresarial portuguesa e os efeitos nas empresas saudáveis e na economia em geral a vários níveis.

Os resultados demonstram duas coisas importantes: i) as empresas zombie representam um congestionamento de recursos de mercado (principalmente tabalho e capital), prejudicando as outras empresas da economia nos dois níveis e levando a uma forte emigração da população ativa portuguesa; ii) quanto maior a percentagem de zombies em um determinado setor, maior será a diferença de produtividade entre as empresas mais dinâmicas e as empresas com fraco desempenho. Esse resultado é preocupante, uma vez que à medida que aumenta a diferença de MFP, maior é a concorrência no setor e mais difícil será a entrada de novas empresas no mercado e a substituição de zombies. Esse é um dos obstáculos à entrada no mercado causados pelo congestionamento das empresas zombies e pode estar relacionado a uma recuperação mais lenta da economia portuguesa após a crise financeira.

Palavras-chave: Empresas Zombies, Desalocação dos Recursos, Produtividade Multi-fatorial, Economia Portuguesa, Recuperação Económica.

Classificação JEL: D24, E22, G21, G32, G33, L25, O16, O4

Abstract

The slowdown in the economic growth of developed countries, the last financial crisis and the slow economic recovery have raised a lot of controversy as population is gradually more educated and technological innovations are getting each time faster.

Thus, the study of zombie firms and their impact on the Portuguese economy is extremely important because of the link between these three major problems. This paper aims to determine the main causes of the appearance, fixation and increase of this type of firms in Portugal; its evolution and importance in the Portuguese business structure and the effects on healthy companies and the economy in general at different levels.

The results demonstrate two important things: i) the zombie firms represent a congestion of market resources (mainly labor and capital), harming the other companies in the economy on both levels; ii) the higher the zombie share in a given industry, the greater will be the difference in productivity between the most dynamic companies and the laggards. That is worrisome because as the multi-factor productivity (MFP) gap increases, the greater is be the competition in the industry, and the harder it will be for new companies to enter in the market and replace the zombie ones. This is one of the barriers to enter in the market caused by the congestion of zombie firms and may be related to a slower recovery of the Portuguese economy after the financial crisis.

Key words: Zombie Firms, Resources Misallocation, Multi-factor Productivity, Portuguese Economy, Economic Recovery.

JEL classification: D24, E22, G21, G32, G33, L25, O16, O40

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Acronyms and Abbreviations

EU - European Union

GDP - Gross Domestic Product

MFP - multi-factor productivity

OECD - Organisation for Economic Co-operation and Development

US - United States

NPLs - non-performing loans

BES – Banco Espírito Santo

CHK - Caballero, Hoshi, and Kashyap

EC - European Commission

SCIE - Sistema de Contas Integradas das Empresas

INE - Instituto Nacional de Estatística

AR - Autonomous Region

MA – Metropolitan Area

SME - small to mid-size enterprise

NACE - Nomenclature of Economic Activities

ICR – Interest Coverage Ratio

OLS - Ordinary Least Squares

ln – natural logarithm

cp - *ceteris paribus*

RMSE - Root Mean Square Error

1. Introduction

After entering the EU, Portugal experienced a period of strong economic expansion and GDP growth at rates of up to 10% per year. However, this growth period was accompanied by both public and private indebtedness, and most of the resources were invested in non-tradable industries (like real estate, health, education, and infrastructure). Moreover, the credit granted to unprofitable projects or to economic agents without sufficient income to pay the credits (or simply bad investments), led to an over indebtedness of the country and consequent financial rescue. This crisis had already shown signs since the beginning of the 21st century, because the average annual growth of Portuguese GDP in the first 15 years remained very close to zero while debt increased.

In addition to the factors mentioned above, economic stagnation is likely to be triggered by other reasons, namely by the increase of zombie firms, and this is what will be analysed in this work. These firms are often referred to as low-productivity firms that would normally close in a competitive market if it were not for bank lending, Andrews et al. (2017). In this way, the ease of obtaining credit, alongside with a long period of very low interest rates, created conditions for the appearance, fixation, and permanence of zombie companies in the economy. Thus, if there are no significant obstacles to obtaining credit from companies and if interest rates are particularly low, then there are conditions that will allow companies to remain on the market without economic viability and with very low productivity. These firms in Portugal seem to be more concentrated in the non-tradable sectors, namely in the Construction and Services sectors, and therefore represent between 5% (2008) and 12% (2013) of the total companies, Barros et al. (2017). Therefore, it's important to determine the impact of these firms in the sectors and in the economies with those characteristics such as the Portuguese one.

Generally, the main consequences of the large number of zombie firms in the market are: (i) imprisonment of production resources (labour, capital and financial resources) and the impediment of their reallocation; (ii) market congestion and the creation of barriers, preventing the entry of new, more innovative and more competitive companies; (iii) decrease in the potential aggregate growth of the economy due to two major factors: decreasing business investment and decreasing multi-factor productivity (MFP). Therefore, there are several reasons to test the hypothesis and deduce the effect of this type of companies in the Portuguese economy.

In section 2 is studied the literature review about the Japanese crisis of the 1990s, since it was the pioneer country confronting this type of problem (increase and permanence of zombie firms), making a

comparison between Japan, Portugal and the rest of the OECD countries, pointing the similarities and the differences.

After that, there will be an analysis of the latest Portuguese data on this topic, mainly of the Portuguese business structure and the proportion of zombie firms in different sectors.

In section 4 is discussed the Amadeus database and is analyzed the Portuguese corporate structure at location level, density, age, main sectors of activity and the number of companies to consider each year. In section 4.3 is calculated the percentage of zombie firms in the Portuguese economy and is studied their evolution during the years analyzed. Zombie capital is also calculated, as well as the sectors of activity where it is more prevalent.

Section 5 presents the econometric model and in section 5.1 are estimated the empirical results and is made a comparative analysis of them with the rest of the literature. Lastly, are presented more consistent models and the main differences in relation to the first ones.

Section 6 concludes with the main results and some final remarks.

2. Historical Background and Antecedents

To better understand how zombie firms work, it is important to study the Japanese crisis of the 1990s, since it was in this crisis that Hoshi first noticed this phenomenon in his paper in 2000. In addition, we can note some similarities between this crisis and the Portuguese case, and make some notable comparisons.

The debate of this problem arose from the stagnation of the Japanese economy in the last decade of the twentieth century, which became known as the "lost decade" (Peek and Rosengren 2005). The background that the literature points to the antecedents of this great stagnation in Japan and the western countries are related to the post-war phase. First, by the end of the golden years and the catch-up phase, developed countries could no longer grow by merely imitating or importing new technologies from advanced economies (such as the US). Well-functioning economic practices and institutions during the catch-up phase were not suitable for a more mature economy, Hoshi and Kashyap (2011). Second, financial globalization and the collapse of the fixed exchange rate regime meant that by the late 1970s countries could no longer rely on currency devaluation to boost exports and their economy. Thirdly, the population structure of developed countries was changing and becoming older and older. Aging and declining fertility have contributed to the slowdown in economic growth and the crisis in the social system of many countries around the world. Thus, the end of the catch-up phase, the globalization and the rapid aging of the population created favourable conditions for the emergence of zombie firms and a major challenge for the world economy.

Besides all these factors, what triggered the crisis in Japan was the sharp decline in stock and land prices, which began in the early 1990s: shares lost around 60 percent of their value between 1989 and 1992, and the price of land decreased by half of its value between 1992 and 2002 (Caballero, Hoshi and Kashyap, 2008). Although these shocks seriously affected the banking system, the Japanese policy and regulatory response denied the existence of problems and delayed any serious reform or bank restructuring, which led to serious long-term implications. At the time, the banks' only obligation was to meet the international standards of their minimum capital level (the Basle capital standards). Thus, the fear of falling below capital thresholds due to default by some companies, made the banks to continue to lend non-performing loans (NPLs) with hope that somehow these companies would recover or the government would help them, so the number of zombie firms increased. Similarly, in Portugal there was also a great stagnation but in the first decade of the twentieth century, associated with a decrease in the inflation rate (and even deflation in 2009), followed by an increase in credits to unsustainable

companies and a lack of effective policy and regulatory response. In Japan, the companies that most received NPLs were large and old firms, which had strong relationships with banks and so higher facility to get loans. Therefore, according to the literature, it's to be expected that this phenomenon will also be verified in Portugal. So, the first step of the appearance of zombie firms resulted due to the perverse behaviour of the financial system.

Banks' failure to recover the so-called roll-over loans also provoked public criticism in Japan as banks were worsening the recession by denying credit to companies that really needed. In fact, the government also encouraged banks to increase lending to small and medium-sized enterprises to alleviate the apparent "credit crisis", especially after 1998. Hence, this ongoing financing, or "evergreening loans", can be seen as a rational response to these multiple pressures, Caballero et al. (2008) and Peek and Rosengren (2005), which indicates that the lack of competent political responses also led to the rise of zombie companies.

This large-scale and long-lasting crisis affected not only zombie firms but also healthy firms in the same industry. According to the literature, keeping this type of firms alive through low rate credit also causes competitiveness problems in the market, since healthy companies do not have access to credits in the same way as zombies. The study by Caballero et al. (2008) found that the market congestion with this type of firms caused a generalized decrease of its products price in Japan and the increase of market wages, which diminished the marginal productivity of the labour factor. This has led to a decline in profits in these sectors, including in the healthy firms, causing discouragement to young and innovative start-ups to entry in the market. This has led even the good banks to struggle to find good lending opportunities in Japan. According to the Peek and Rosengren (2005) study of "evergreening loans" in Japan, the poor distribution of credit to troubled companies is associated with both internal problems of the financial system, and external (government pressure on banks).

Thus, the government liability that came from guaranteeing the deposits of banks that supported zombie firms was a very inefficient program to sustain the Japanese employment.

Due to this lack of response of political and regulatory action on this issue, the problem worsened and it was necessary to recognize bankruptcy and its nationalization in 1998, Hoshi and Kashyap (2000). In the same way, the situation presents some similarities to what happened in Portugal during the last financial crisis. Initially, banks granted loans very easily to businesses and households, even if they were unable to repay them in the future. This gradually led to the rise of zombie companies as they

were backed up by low interest loans in order to not close them and account as losses for the banks. With the impact of the global financial crisis, the problem became unsustainable, which led to the bailout and later, in 2013, to the capitalization of some banks (BES) and a provisional public administration of them.

In the same way that Japanese banks did not find good investment opportunities, a similar phenomenon occurred in Portugal. Due to the banks lack of technical skills to evaluate good projects, the more dynamic Portuguese companies (that have a greater potential of growth) had a great difficulty to resort to external financing funds, Alexandre et al. (2017). However, these results may reflect a more conservative option of financial management of Portuguese companies, since the period under review was preceded by a serious financial crisis.

3. Definition of Zombie Firms

In practice, it is not always easy to distinguish a zombie firm from a healthy one, so a classification method must be adapted according to the available information (database) and able to correctly classify all the companies in the sample. However, several methods were inspired by the model used in the Caballero et al. (2008) study, which is adapted in a considerable amount of studies (Fukuda and Nakamura, 2011; McGowan et al. 2017; Barros et al., 2017; Gouveia and Osterhold, 2018).

The book by Alexandre et al. (2017) is based on a method that consists in two criteria to define whether a firm is zombie or not. First, it calculates if this company receives such "subsidized credit", according to the methodology defined by Caballero et al. (2008), the CHK criterion. Second, if the company's profit is lower than the hypothetical risk-free interest payments, Fukuda and Nakamura (2011). Therefore, in order to determine if the firm receives such subsidized credits, it must be defined what would be the risk-free interest, i.e., the minimum market interest that a company would pay if it had no risk of insolvency. If the average interest the company pays is less than this minimum interest, then the CHK criterion classifies it as a zombie.

The minimum interest is defined by the following expression:

$$\boldsymbol{R^{*}_{i,t} = rs_{t-1} \cdot BS_{i,t-1} + \left(\frac{1}{5}\sum_{j=1}^{5} rl_{t-j}\right) \cdot BL_{i,t-1} + rcb_{5years,t} \cdot Bonds_{i,t-1},} \qquad (1)$$

where $BS_{i,t}$, $BL_{i,t}$ and $Bonds_{i,t}$ are short-term (less than one year) bank loans, long-term (over one year) bank loans, and total bonds outstanding (including convertible and warrant-attached bonds) of firm *i* at the end of year *t*, respectively. The interest rates rs_t and rl_t are the average short-term and long-term prime rate for year *t*, respectively and $rcb_{5years,t}$ is the minimum observed rate on any convertible corporate bond issued over the previous five years prior to *t*.

However, there is a risk of classifying good companies as zombies just because they work well and have a relatively low interest cost. Thus, according to the second criterion, if the company's profit covers the subsidized amount, then the company is reclassified as a non-zombie.

The results of this study indicate that the percentage of zombie companies in Portugal increased during the crisis, reaching a maximum of 35.5% of Portuguese companies in 2012, followed by a strong annual reduction of approximately 3 percentage points, reaching 26.1% by 2015. However, these results indicate that most zombie companies were concentrated in small and medium-sized

enterprises[1]. In 2012, around 37% of Portuguese companies with less than 10 workers were classified as zombie, while in companies with more than 250 employees this percentage was only 22%, which is inconsistent with rest of the literature. This difference may result from the age restriction posed by more recent studies (e.g. McGowan et al., 2017), since it is difficult to distinguish zombie companies from innovative start-ups firms only on the basis of profitability criteria.

Thus, in the OECD study by McGowan et al. (2017), was used a simplified version of the CHK criterion:

$$R_{i,t}^{*} = rs_{t-1} \cdot BS_{i,t-1} + \left(\frac{1}{5}\sum_{j=1}^{5} rl_{t-j}\right) \cdot BL_{i,t-j}, \quad (2)$$

since this version is less demanding in terms of data. The CHK criterion implies a detailed knowledge of each company's debt distribution, which is often unknown, as is the case in the database available from the OECD countries. In addition to the CHK criterion and the company's restriction being at least 10 years old, McGowan's study still uses operational features to identify companies with persistent financial weakness. Thus, a firm with an interest coverage ratio less than one (the ratio of operating income to interest expenses) for three consecutive years is classified as a zombie (Bank of Korea, 2013). The three-year interest coverage condition is important to address the business cycle effects on the prevalence of zombie firms. The adoption of this last criterion was also due to three main reasons: (i) greater facility in comparing the coverage ratio between companies of different countries; (ii) the interest coverage ratio is less endogenous to productivity than negative profits; and (iii) this ratio also includes alternatives besides the "subsidized credit", through which zombie firms are kept alive.

3.1. The Density of Zombie Firms in Portugal

Gouveia and Osterhold (2018) and Barros et al. (2017) adopted a methodology very similar to the OECD paper for the classification of zombie firms, considering the interest coverage ratio lower than one for three consecutive years, and the age equal or higher than 10 years. In the first study, the percentage of this type of company varied between 6.5% (2008) and 9% (2013), and this percentage

[1] For the enterprises sized definition, is followed the Recommendation 2003/361/EC given by the European Commission on 6 May 2003, to micro, small and medium-sized enterprises.

decreased to 7.5% in 2015. However, these percentages cover large sector differences regarding to the presence of zombie firms, ranging from 3% (in professional, scientific and technical activities) and 13% for the accommodation and food service industry.

Also according to this study, the percentage of work sunk in zombie firms in this period was around 15%, with an increase of 2 percentage points in 2013. Regarding the capital sunk, the lowest value was recorded in 2010, with only 20% of Portuguese capital stuck in zombie companies, followed by the upwards trend until 2013 with a value of almost 30%, followed by a decrease until 22%.

As the weight of labour and capital sunk in zombie firms was significantly higher than the percentage of these firms in the total economy, can be conclude that most of these firms were large, which corresponds with the literature, which states that the oldest and larger companies have stronger links with the banks and, therefore, easier access to credit.

This study also demonstrated an increase in the productivity gap of the labour factor between the most dynamic Portuguese companies and the others (laggards), which is in accordance with the results of McGowan et al. (2017) for labour factor productivity in several OECD countries with this kind of problem over the last decade. The recent strand of literature is focusing on the role of zombie firms that, by capturing resources into unproductive activities, drag aggregate productivity down, which may explain those results.

Regarding the study of Barros et al. (2017), it only focuses on companies in the non-transactional sector (about 180 thousand companies), so comparisons can only be made between this sector and the rest of the economy, that is, tradable sectors. The period under analysis was between 2008 and 20015, representing a percentage of zombie firms of 5% and 11%, respectively, showing a peak of 12% in 2013. Regarding the capital stuck in these companies, the same pyramid behaviour was observed, with a peak in 2013 representing about 10% of the capital of the Portuguese economy.

This indicates that, in 2013, the number of zombie firms in the non-tradable sector was higher than in the rest of the economy, pointing out that this sector was less efficient than the others. However, the capital stuck in this sector was 20 percentage points lower than the rest of the economy, which indicates that these companies are relatively smaller and do not have so much weight in the Portuguese economy.

The most alarming fact is that the percentage of zombie firms increased during the crisis, while the total number of companies was decreasing, so this may have two interpretations: (i) the number of companies that became zombie was higher than the number of zombie companies that closed; (ii) or the number of such firms remained constant, which increased their share as the total number of firms decreased - revealing in this case an extraordinary inefficiency of the "market clearing mechanism", Barros et al. (2017).

4. Data Description and Characterization

4.1. Data Base

In this study was used Amadeus database, which contains comprehensive and comparable financial information for public and private companies across Europe. However, this database does not contain information on three major aspects, which will condition and greatly harm the results.

The first problem concerns the interest rate paid by the companies. Since the mentioned database does not have information about the interest rate that companies pay for the credits received, it is impossible to apply the CHK criterion used by Caballero et al. (2008) and several other OECD studies to assess risk-free interest and, consequently, companies that pay interest less than that level. Thus, it is impossible to determine companies with access to subsidiary credits. However, we may use other measures to identify zombie companies, as we will see in section 4.3.

Moreover, Amadeus only contains information of the most recent year "living" companies at the time of the sample collection. Thus, companies that have already gone bankrupt are permanently deleted from the database. That said, the number of companies in the sample can only have a positive trajectory over the years, which does not allow to know the variation in the number of companies and thus, draw conclusions about the effect of zombie companies on this variable.

Finally, the database contains company information for the last 10 years. That is, it is impossible to select pre-crisis data for a broader and more complete analysis of zombie business developments throughout the financial crisis period.

4.2. Descriptive Statistics

To better analyze the effect of zombie companies on the Portuguese economy, was collected a sample of 462,498 firms representing all active companies in Portugal available in Amadeus until 27 September 2019.

Since the last financial crisis and the slow economic recovery are to be analyzed in more detail, it was decided to use economic-financial microdata at the level of Portuguese companies (pooled[2]) during the years when the crisis was most severe, *i.e.*, between 2010 and 2019 (panel[3]).

Posteriorly, the database was "cleaned up", where observations that were not of interest were gradually excluded. Thus, initially 5,793 companies were withdrawn, as it had no tax identification

[2] Pooled data is a mixture of time series data and cross-section data.

[3] Panel data is multi-dimensional data involving measurements of a given unit over time.

number, remaining only 456,705. The 2019 samples were also excluded as most companies had no data for that year yet. Finally, it was found that many companies failed to report essential economic and financial data (such as assets, capital, number of employees, interest expense, etc.) for several consecutive years. Since these data is crucial for the study in question, these observations were also eliminated, leaving a total of 353,844 companies considered and proceeded for a general analysis of the sample.

Table 1 – Number of Firms Considered by Year

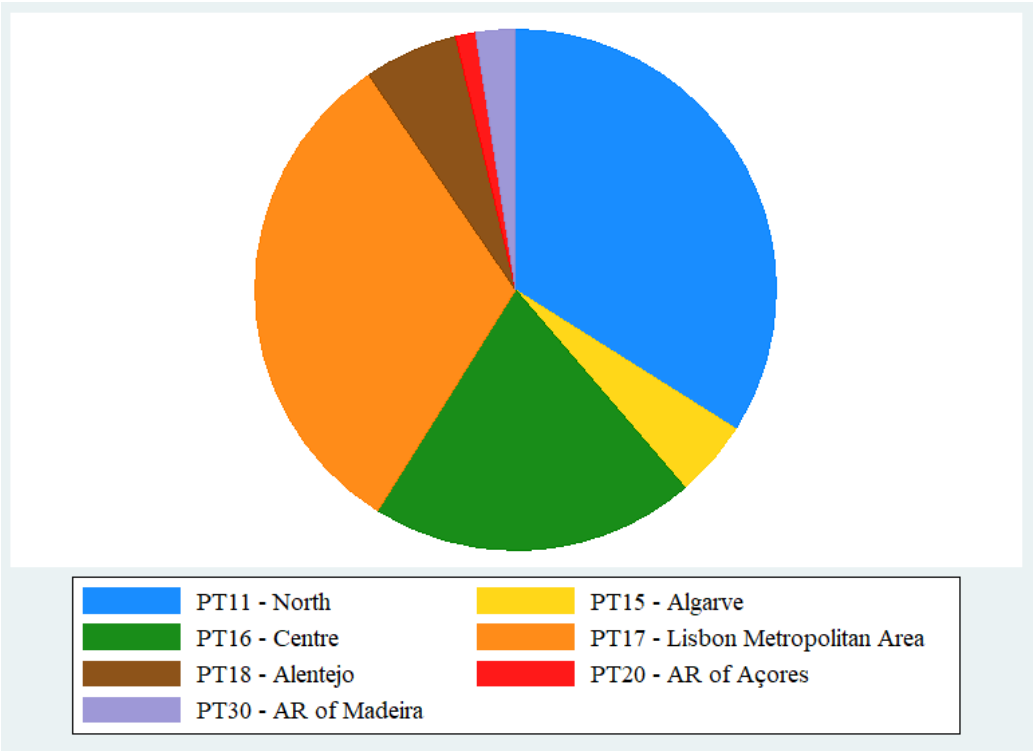
Year	Freq.
2010	197,728
2011	215,252
2012	233,613
2013	255,429
2014	271,228
2015	290,278
2016	309,118
2017	321,390
2018	287,172

Source: Authors' calculations

As explained on the previous section, Amadeus does not keep in the database the companies that have already gone bankrupt. Thus, it is normal that the number of considered firms to have a positive evolution, as shown in table 1. However, in the last year there has been a decrease in the sample. This is due to the fact that many companies are late in reporting all data and are left out of the considered companies.

As shown in the figure 1, most Portuguese companies are located in the North, representing around 34% of all companies, and approximately 18% of them are part of the Porto metropolitan area, i.e. around 6 percentage points. Slightly below is the Lisbon metropolitan area, which reaches 31.5% of Portuguese companies and thirdly the Center, with only 20%. The Autonomous Region of the Azores is the NUTS 2 with the smallest number of companies, representing only 1.3% of them.

Figure 1 – Distribution of Portuguese Companies by NUTS 2



Source: Authors' calculations

Regarding the size of the companies, it follows the Recommendation 2003/361/EC given by the European Commission on 6th May 2003, to micro, small and medium-sized enterprises, as mentioned in section 3.1. Thus, companies are divided into 4 broad categories, where their size is defined (on the one hand) by the number of workers employed:

1) Micro enterprises, where the number of employees is 10 or less;

2) Small companies employing from 20 to 49 workers;

3) Medium-sized companies, which have between 50 and 249 employees;

4) Large companies with 250 or more workers;

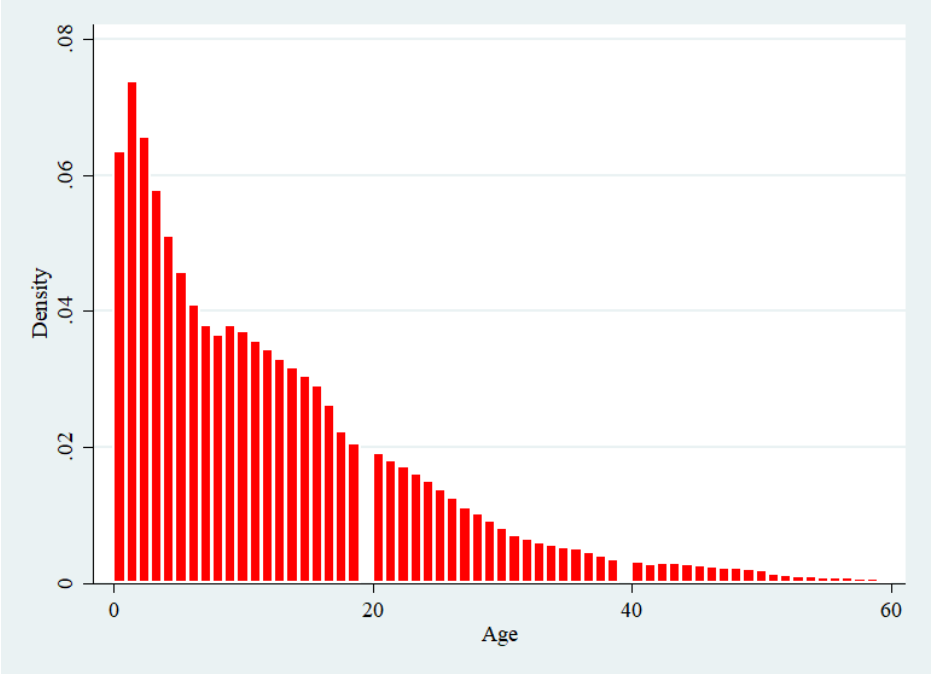
That said, it was found that in Portugal, approximately 86% of companies are classified as micro enterprises. In other words, they have 10 or less workers, and the minimum registered value is of 1 employee. In the smallest percentage are the large companies (with more than 250 employees), which represent only 0.36% of the Portuguese companies. The largest company has 45,231 employees. Thus, we can conclude that 99.64% of companies in Portugal are micro, small and medium size enterprises.

These figures are quite common, as in 2013 around 99.8% of the EU businesses were considered small and medium-sized enterprises (SMEs), according to Eurostat.

However, in the regressive models will be used 6 different subcategories for the firm size, to have a greater sensitivity in the relation between the firm size and the dependent variables. These subcategories are represented within the following values: 1-10, 11-19, 20-49, 50-99, 100-249 and 250 or more.

Regarding the age of companies, we can see in figure 2 that we have a very young sample, where 10% of companies are under one year old and half of them are under 10 years old. Only one tenth of the firms are over 30 years old. It should be noted that the distribution of data is slightly biased to the right as the average of the sample is 13 years old. This is caused by some outliners, such as the sample's oldest company, which is 519 years old, which "pulls" the average to the right of the median.

Figure 2 – Density of the Portuguese Firms by Age (Fixed for Outliners)



Note: Spaces separate two decades for easier visualization.

Source: Authors' calculations

Regarding the Portuguese business structure, companies were classified according to their main economic activity and according to the European commission classification (NACE code). Thus, the “wholesale and retail trade” sector, which is the most frequent economic activity in Portugal, can be

highlighted, representing a quarter of all companies (25%). Several sectors of the Portuguese economy hold around 10% of all companies, each, such as the construction sector, the manufacturing sector and the "professional, scientific and technical activities" sector. Is also notable that 8% of Portuguese companies are linked to real estate activities and the three economic sectors with the lowest percentage of companies in Portugal are the mining, public administration and extraterritorial organizations and bodies, which represent 1.33%, 0.19% and less than 0.01%, respectively.

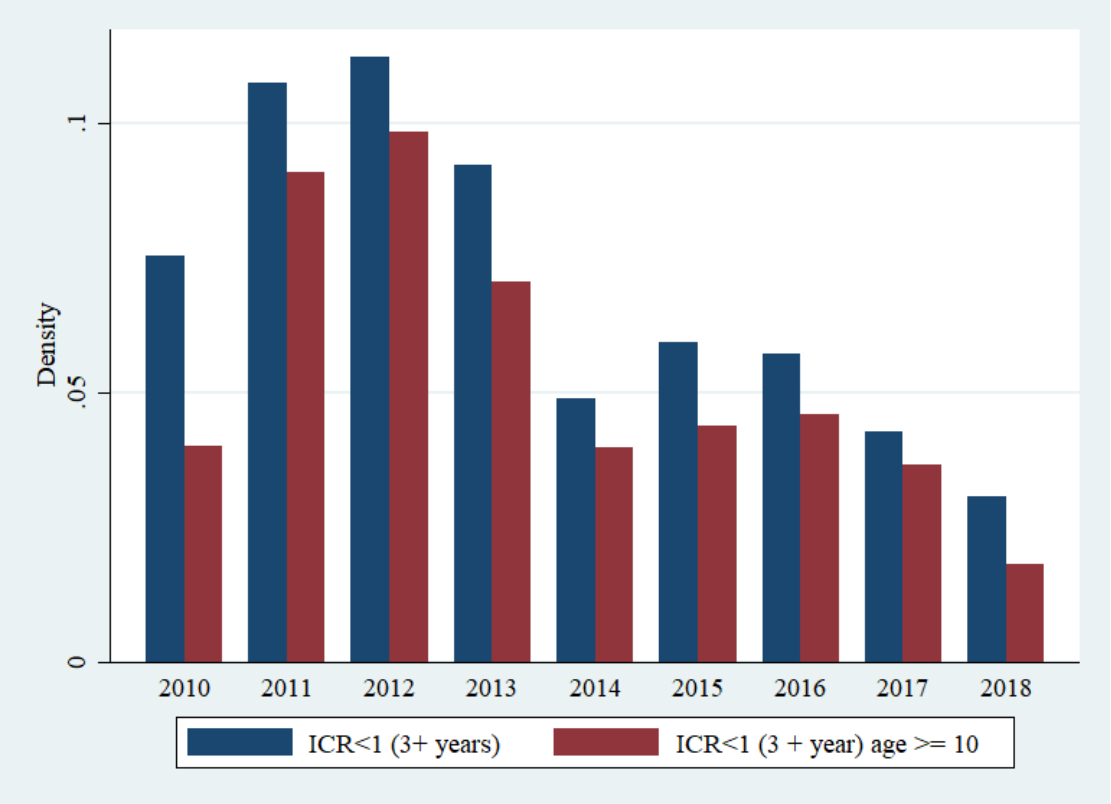
4.3. Calculation and Description of Zombie Firms in Portugal

As mentioned in section 4.1, the database does not contain information about the interest rate paid by the companies. Therefore, we cannot use the CHK criterion to identify zombie companies. Thus, other criteria were used, depending on the available information, namely the interest coverage ratio (ICR) lower than 1, for at least three consecutive years (Bank of Korea, 2013) and the age of 10 years or older (McGowan et al., 2017).

As shown in the figure 3, the percentage of zombie firms between 2010 and 2018 vary between 1.8% (2018) and almost 10% (in 2012) of the Portuguese companies, with an average rate of 5.22% during the period. Regarding the evolution is observed a downward cyclical behavior. In other words, from 2010 to 2012 there is an increase in the percentage of zombie companies, followed by a sharp decline until 2014. And from 2014 to 2018 there is a repetition of this upward and downward behavior but on a smaller scale. Thus, we can say that we have two peaks: a main one in 2012 where zombie companies represent 10% of the companies in the Portuguese economy; and a secondary one in 2016, where this percentage is only 4.6%. In general we have a downward trajectory of zombie companies which indicates a good sign for the Portuguese economy and a better cleansing mechanism.

We can also observe a parallelism between the zombie firms and the companies that have been in the market for less than 10 years and have an IRC lower than 1 for at least 3 consecutive years, however the difference between the two categories is greater during the first years, where the crisis was more pronounced. That means that during the crisis the young firms had more trouble and could have been classified as zombie if there was no age restriction.

Figure 3 – Zombie Firms Prevalence



Note: ICR means interest coverage ratio and "age >=10" represents the condition of the firm being 10 years or older.

Source: Authors' calculations

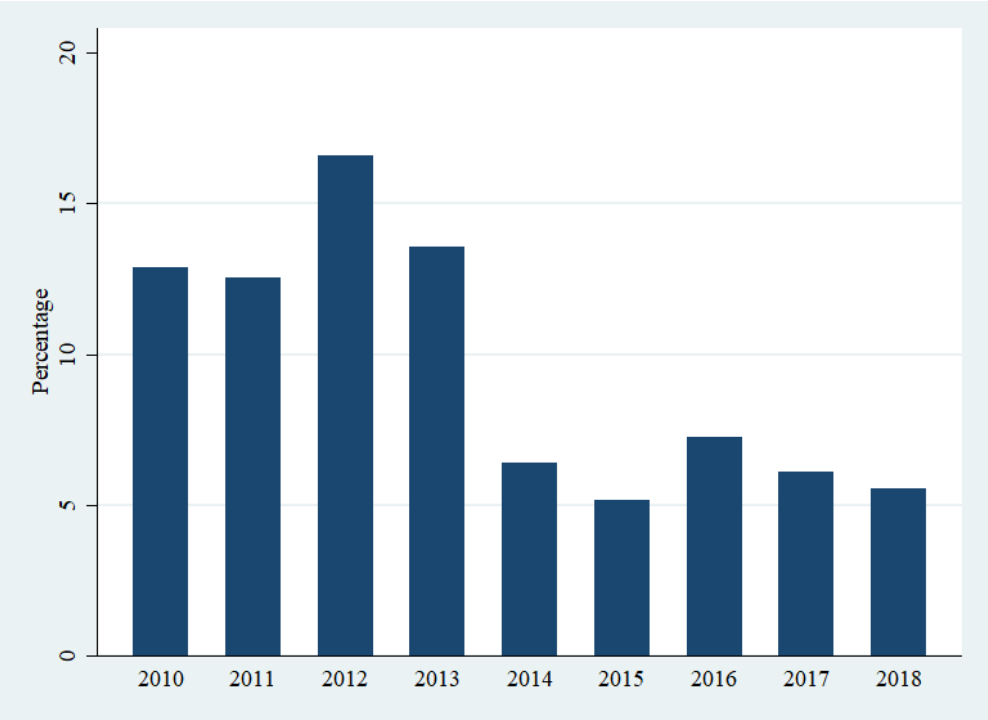
Although the trajectory and peak year of zombie firms is similar to the rest of the literature, Barros et al. (2017), the percentage of these companies in the Portuguese economy is slightly lower than expected (around 15% peak). One of the reasons for this low value may be because the period under review only captures the final part of the crisis. The second hypothesis is that Amadeus eliminates bankrupt companies from the database, i.e. at the time of the sample collection (September 2019) zombie firms that left the market during the last crisis had already been excluded from the database at the time of the collection. The third reason for this low value may be due to the elimination of observations that did not report crucial economic and financial data for some years. Thus, it may be difficult to ascertain companies that have had a coverage ratio lower than 1, for 3 consecutive years, if in some year(s) in between they failed to report financial data.

However, the number or percentage of zombie companies is not always the most important factor in this matter, but the "sunken" capital in zombie companies, i.e. the capital that these companies own.

This is extremely important because it represents the machines and resources that could be used by efficient companies but are sunk in zombies. This also implies capital market congestion in the sectors where these zombie firms are located.

As can be seen in the figure 4, the average percentage of sunken capital in zombie companies across different sectors of the Portuguese economy is much higher than the percentage of zombie companies. These numbers are already closer to the values found in different studies, such as the OECD publication by McGowan et al. (2017) and Barros et al. (2017).

Figure 4 – Average Capital Sunk in Zombie Firms by Sector



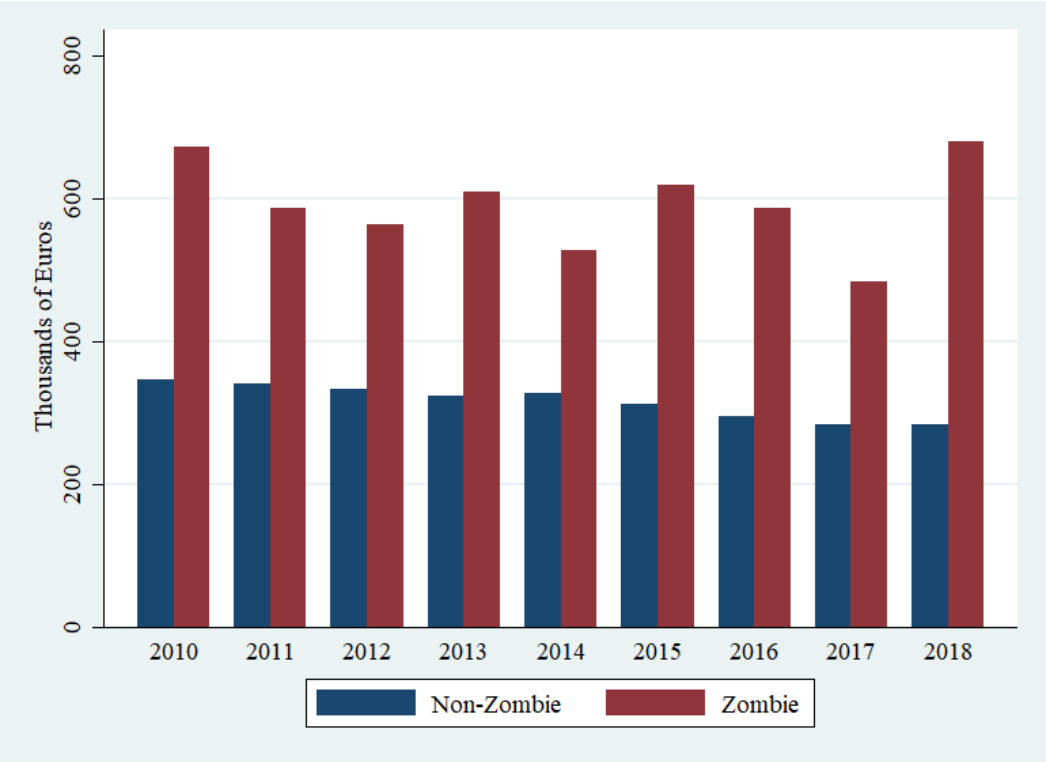
Source: Authors' calculations

Because the percentage of capital sunk in zombie firms is much higher than the percentage of zombie firms in the economy, it means that zombie companies are in general big companies with great amount of capital. That confirms the general theories, in which zombie firms are normally old companies of big dimensions. Comparing these last two charts we can also see that in all years the percentage of "zombie capital" is higher than the percentage of the zombie firms. In 2010, the zombie capital is even the double of the percentage of zombie firms. That means that during the crises more firms were considered zombie, and more capital was sunken in them. To better understand the difference between the dimension of zombie firms and the rest of the companies in the economy, and

the amount of sunken capital in this kind of firms, is important to calculate de average capital sunken in zombie firms in the Portuguese economy.

In figure 5, the average of zombie capital is higher than the capital of healthy companies in all the analyzed years. In some years, the average zombie capital is almost than the double of the average of the healthy capital (2010, 2013, 2015 and 2018). This confirms that most zombies are companies with a great amount of capital, i.e. large companies.

Figure 5 – Average Capital of Portuguese Firms



Source: Authors' calculations

It should be noted, however, that while the percentage of zombie firms increases from 2010 to 2012, the average zombie capital (figure 5) decreases over that period of time. This means that in those years a high number of small firms turned into zombie, lowering the average capital of zombie. That can be easily understood because 2012 was the peak of the Portuguese economic crises, more firms had financial difficulties so even companies considered healthy were damaged and classified as zombie. In fact, if we compare figure 3 and 5, the average zombie capital has an opposite movement compared to the percentage of zombie firms. That is clearer on the first "cycle" than on the second one, as more firms turned back to healthy firms on the last years analyzed, remaining classified as

zombie mostly the same old companies before the crisis. That can be a reason why the average zombie capital is similar on 2010 and 2018.

Since we know the age and size of zombie companies in Portugal, is left to be seen in which part of the economy these companies are located, i.e. in which sector. This is one of the most important aspects of the analysis as it indicates the sectors with the greatest economic problems and where is located the so-called market congestion. In addition, it points out the industries where political intervention might be needed, as the market cleansing mechanism in those sectors is inefficient. Thus, we can highlight the sectors that have a larger rate of zombie companies.

With the highest percentage of zombie firms we have the "Public Administration and Defense" sector (O[4]), with an average of 9.52% of companies being zombie. In second is the "Accommodation and Food Service Activities" industry (I), whose share of zombie firms is 9.07% and in third is the education sector (P), with 7.40% of the firms classified as zombie. Although these sectors are high above the average rate of zombie firms in Portugal during the analyzed years (5.22%), the most important is the evolution of that zombie rate in the analyzed years and the capital they share in the respective market. Thus, in table 2 are represented the percentage of zombie firms of those 3 sectors, by year.

Table 2 – Sectors with the Highest Percentage of Zombie Firms

Year	O	I	P
2010	4.76	6.67	4.80
2011	13.63	15.24	12.17
2012	8.33	17.59	13.21
2013	7.69	13.21	10.01
2014	4.00	8.33	6.23
2015	6.45	8.32	6.72
2016	11.42	8.02	7.12
2017	13.79	5.86	5.76
2018	16.67	2.57	2.63
Mean	9.52	9.06	7.40

Source: Authors' calculations

[4] O, I and P represent the activity sector according to the European Commission's NACE code classification.

As shown in table 2, in sector I and P the percentage of zombie companies increases until 2013, where it takes an opposite movement and continues to decline until 2018, where only registers 2.57% and 2.63% of zombie firms, respectively. These values are much lower than the overall values and lower than the average of the analyzed period. This indicates that while these sectors have suffered the most from the last economic crisis, they now have a much lower percentage of zombie companies and that the market cleansing mechanism has worked.

However, in sector O it can be seen that initially, the share of zombie firms behaved in the same way as the other sectors, but in 2015 there is a breakdown of this downward movement and the percentage of zombie companies begins to rise every year until 16.67% in 2018. The most worrying is that sector O represents the "Public Administration and Defense", which may show evidence of a new public crisis.

Regarding the zombie capital in these industries, the estimated values were very close to the percentage of zombie companies.

Although the construction and the services sectors in Portugal were expected to have a high percentage of zombies, as was pointed out in other studies (Barros et al., 2017), these industries are recovering and shown a downward trajectory regarding the share of zombie firms in 2018. Meanwhile in the construction industry the share of zombie firms is near the national average (5.54%), the services sector has still a high overall percentage of zombies (7.24%).

"Mining and Quarrying" sector is the industry with less percentage of zombie firms in the analyzed period, with a share of only 0.22% of zombies and the "Administrative and Support Service Activities" and the "Activities of Extraterritorial Organisations and Bodies" sectors have no zombie companies.

Once again, this low numbers in the percentage of zombie firms by sector may be due to the same reasons pointed out on the identification of the zombie firms and on the section 4.1.

5. Methodology

To empirically measure the effect of zombie firms in the Portuguese economy, will be used the linear regression model. In this study, the basic specifications of the model were inspired in papers like Caballero et al. (2008) and McGowan et al. (2017) and can be represented as follows:

$$Y_{ist}^{k} = \beta_0 + \beta_1 nonZ_{ist} + \beta_2 nonZ_{ist} \cdot Z_{st} + \beta_3 Size1_{ist} + \beta_4 Size2_{ist} + \beta_5 Size4_{ist} + \beta_6 Size5_{ist} + \beta_7 Size6_{ist} + \beta_8 Young_{ist} + \beta_9 Period1_t + \beta_{10} Period3_t + \delta_{ist} + \varepsilon_{ist}, \quad (3)$$

where: *Y* refers to a measure of activity (the investment rate, the percentage change in employment or the level of multi-factor productivity; *k* = 3) in firm *i*, in industry *s*, at time *t*; *nonZ* is a dummy equal to 1 if a firm is a non-zombie firm; *Z* is the share of industry capital sunk in zombie firms; *Size* includes dummies for firm size (1-10, 11-19, 20-49, 50-99, 100-249 and 250+); *Young* is a dummy for firm age (young = 1 if age < 6); *Period* is a set of two dummies for the years analysed and ε_i is the white noise error term. The model also controls for interacted industry and year fixed effects to control for time-varying specific shocks.

The main objective of the model is to test the harmful effects of an increase in zombie prevalence in the activity of healthy firms. Thus, the main coefficient of interest is β_2, because is the interaction, i.e. the effect that the capital sunk in zombie firms have on the healthy firms, in different sectors of the economy. It is expected that the coefficient of this variable to be negative for both investment and employment, since the retention of resources (labour, capital and loans) by zombie firms makes it difficult to relocate them to companies that are more efficient in that sector.

The multi-factor productivity (MFP) is an empirical productivity growth measure based on the Solow residual. According to this method, the productivity growth is a gain on the output with constant capital and labor input. It is a "residual" because is the part of growth that is not accounted by measures of capital accumulation or increased labor input. Most of the literature defines it as the know-how gained with experienced and education or an improvement on the technology. Thus, for the MFP the model predicts a positive β_2, which means that in sectors with a higher zombie presence the productivity gap between zombie and healthy firms increases.

Regarding to β_1, it cannot be made great predictions, since zombie firms can invest more and employ more workers due to the subsidized credits that facilitate such behaviours. However, when it comes to the level of multi-factor productivity, it is expected to have a positive value.

About to β_3, it will be separated in the 6 different subcategories (described in section 4.2.) and the sign of the coefficients cannot be entirely predicted, although in the first 2 models the values may have a negative indicator, as the subcategory is on a higher level. This is because larger companies have less necessity to invest and hire workers than smaller and new companies, which are still growing in a faster way. Regarding it behavior in the third model, it is expected to have a positive coefficient as the size grows, because the larger the company, the greater the economy of scale and the greater the know-how due to more accumulated experience, which boosts the MFP.

With regard of β_8, it is expected to be associated with high investment rates, as this variable represents the young companies which are still in the growth phase; and a high level of employment. For the third model, the result can be ambiguous or even negative. Moreover, the MFP cannot be calculated if inputs are constantly changing and small and young companies will not have such a high level of economies of scale as the rest of the firms. In addition, it also depends on how young companies are, as companies aged 5 could already have some economies of scale. Thus, regarding the β_8 coefficient in the third model, the result is ambiguous.

The last variable represents a dummy with 3 periods of time for the years analysed (2010-2012, 2013-2015, 2016-2018), which can be seen as a general behavior of the dependent variable over each period of time. Thus, it can also be seen as an economic indicator, as it shows the financial evolution of the Portuguese firms (zombie or not) during these analyzed years. Because in this study are only captured the last years of the crisis and the post crisis period, and Portugal had a constant GDP growth from 2015, it is expected the β_{10} to have a positive indicator in the last period.

5.1. Empirical Results and Models Consistency

Table 2 shows the estimation results of the OLS models discussed in the previous section. For the three modes we have the same explanatory variables, changing only the dependent variable. In the first model, the investment rate is calculated by dividing the annual variation of total assets by the available capital, Egger and Erhardt (2014). In the second model, employment growth is calculated by the simple annual variation of the labor. In all three models, the coefficient values of the dependent variables are in the natural logarithm (ln). Industry zombie percentage is based on the share of capital sunk in zombie firms (see section 4.3.).

Table 3 – Zombie Capital and non-Zombie Firm Performance: OLS Models

	OLS1	OLS2	OLS3
VARIABLES	Dln(I/K)	Dln Emp	MFP
nonZ_{it}	0.765***	-0.0634***	1.478***
	(0.0254)	(0.0151)	(0.0366)
nonZ_{it} x Z_{st}	-0.0154***	-0.00143	0.0407***
	(0.000451)	(0.000316)	(0.000285)
$\text{Size}_{it} = 1$	2.354***	1.669***	-2.275***
	(0.0115)	(0.00515)	(0.0112)
$\text{Size}_{it} = 2$	0.929***	0.550***	-0.826***
	(0.0145)	(0.00614)	(0.0135)
$\text{Size}_{it} = 4$	-1.005***	-0.493***	0.968***
	(0.0233)	(0.00927)	(0.0284)
$\text{Size}_{it} = 5$	-2.101***	-0.833***	1.926***
	(0.0297)	(0.0117)	(0.0469)
$\text{Size}_{it} = 6$	-3.526***	-1.195***	3.123***
	(0.0420)	(0.0163)	(0.0930)
Young_{it}	2.586***	0.587***	-0.363***
	(0.00551)	(0.00391)	(0.00385)
$\text{Period}_t = 1$	-0.260***	-0.0953***	-0.0440***
	(0.00792)	(0.00543)	(0.00461)
$\text{Period}_t = 3$	0.248***	-0.00346	0.0767***
	(0.00588)	(0.00397)	(0.00413)
Observations	910,223	298,331	900,625
R^2	0.316	0.489	0.114
RMSE	2.4435	0.9429	1.6435

Note: *Z* refers to the share of industry capital sunk in zombie firms, defined as firms aged ≥10 years and with an interest coverage ratio lower than 1 over three consecutive years. *Dln (I/K)* refers to the investment ratio, i.e. the ln difference of the real capital stock; *Dln Emp* refers to the natural logarithm of change in employment and *Ln MFP* is the level of multi-factor productivity based on the Solow-residual. Standard errors in parentheses: *** denotes statistical significance at the 1% level, ** significance at the 5% level, * significance at the 10% level. In parentheses are reported the standard-error.

Source: Authors' calculations.

In the first model we can see that an increase in the zombie capital share at the industry level (β_2) is associated with lower investment for the average non zombie firms, because the coefficient of the interaction is negative. Therefore, the higher is the capital sunk in zombie firms the lower will be the investment rate of the healthy firms in that industry. Thus, on average, when the share of capital sunk

in zombie firms increases by one percentage point, the investment rate of healthy companies in that sector decreases by 1.54%, *ceteris paribus*.

Because this variable is the most important on the model, was used an individual significance test, also known as the *t* test, to verify if is statistically significant. In this test the null hypothesis (H_0) is:

H_0: β_2=0, and

H_1: $H_0 \neq 0$.

In this test H_0 is rejected if $t_{obs} > t_{crit.}$

$$t_{obs} = \frac{\widehat{\beta}_2 - \beta_2}{\widehat{se}\,(\widehat{\beta}_2)} \sim t_{crit} = t_{n-k,\alpha}$$

We got $|t_{obs}| = 9.42$ and t_{crit}[5] = 1.96 (with α = 5%), so $t_{obs} > t_{crit}$, thus H_0 is rejected. This means that β_2 is individually significant. As was made for β_2, it can be made for all betas.

In relation to the first variable, since it is a dummy, it is important to calculate the expected value. That is, the result between the difference of the OLS1 model when *nonZ* = 1 and when *nonZ* = 0. Since the result is 0.765 – 0,0154(Z), it means that, if there is no capital sunk in zombie firms on that industry, non-zombie companies invest, on average, 76.5% more than zombie firms, keeping everything else constant.

Regarding the *Size* set of dummies, we defined the base category as the third subcategory[6], which includes firms that have between 20 and 49 employees. That said, we can conclude that, for example, firms from the second subcategory invest, on average, 93% more than the companies from third category, *cp*. According to the model results, the higher is the subcategory, the lower will be the investment rate.

[5] According to Table 7 of Appendix.

[6] According the Recommendation 2003/361/EC given by the European Commission on 6th May 2003 about subcategories of firms' size, regarding the number of employees: 1-10, 11-19, 20-49, 50-99, 100-249 and 250 or more.

On the other hand, younger companies (less than 6 years old) tend to invest 258.6% more than the older firms, *cp*, which is consistent with the previous variables and the literature.

Regarding the last variable, we can conclude that, on average, in the first period the Portuguese companies invested 26% less than the second period, keeping everything else constant. And then on the third period they invested about 25% more than the second period, *cp*. This means that, the overall investment of the Portuguese firms had a positive evolution during the analyzed period.

Although the results are consistent with the rest of literature, it is crucial to test their statistical validity. For this, some test and reference indicators will be used to evaluate the relevance of the regression. In the first model we can use the global significance test, which tests whether at least one of the regressors is significant to explain our dependent variable. To compile this test, was used the test statistic F. In this test the null hypothesis (H_0) is:

H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = 0$, and

H_1: H_0 is not verified.

In this test H_0 is rejected if $F_{obs} > F_{crit.}$

$$F_{obs} = \frac{ESS/(K-1)}{RSS/(n-k)} = \frac{\frac{R^2}{(k-1)}}{\frac{(1-R^2)}{(n-k)}} \sim F_{crit} = F_{k-1,n-k,\alpha}$$

Because F_{obs} = 38193.83 and F_{crit}[7] = 1.83 (with α = 5%), the $F_{obs} > F_{crit}$, thus H_0 is rejected. This means the first model is globally significant. This could also be verified because all the independent variables are statistically significant with a P-value lower than 1%, as we can see on table 2.

An important indicator of the regression models is the R^2, which indicates at what percentage level the explanatory variables can explain the variance of the dependent variable. As in this model R^2 = 31.6%, it means that about 32% of Portuguese companies investment between 2010 and 2018 is explained by the independent variables of the OLS1 model.

[7] According to Table 6 of Appendix.

One of the assumptions of OLS model is that the variance of the error term is constant, called homoscedasticity. However, if this condition is not verified we are facing a heteroscedasticity problem, which means that the coefficients become inefficient and the variance of the error terms is biased. To detect if the first model has heteroscedasticity we used the Breusch-Pagan/Cook-Weisberg test, and the null hypothesis (H_0): "constant variance", was rejected. That means that the coefficients are less precise and there is a chance that we can't trust the statistical results.

To test if the model has more problems was also calculated the Variance Inflation Factor (VIF) to verify the possible collinearity and / or multicollinearity among all independent variables included in the model. Multicollinearity is when there is correlation between independent variables in a model. Thus, the VIF estimates how much the variance of a regression coefficient is inflated due to multicollinearity in the model. In this study was considered that VIF values close to 1 means there is no correlation. Values between 1 and 5 are considered moderately correlated, and greater than 5 means it is highly correlated. As the test result indicated that the mean VIF is 1.79, we considered there is no multicollinearity in the model.

Regarding the second model, we can see that the coefficient of the interaction variable is negative, which means that the share of zombie capital in a given industry has a negative effect on the employability of healthy companies. If we derivate the second model in order of Z we see that, on average, when the share of capital sunk in zombie firms increases by one percentage point, the employment rate of healthy companies in that sector decreases by 0.14%, *cp*. Thus, the higher this percentage of zombie capital in the industry, the lower the growth of the labor factor in non-zombie companies in that industry. However, because the statistical significance is higher than the 10% level, it means that cannot be mate big assumptions about the variable and more consistent models are needed.

The first variable of the OLS2 model indicates that zombie firms have a higher employment rate than the other companies: on average, it is 6.3% higher, when the capital sunk in zombie firms is zero and keeping everything else constant. This result is not a surprise, as the zombie firms can hire more employees due to the "subsidized credit", Caballero et al. (2008).

Regarding the size set of dummies they have a similar behaviour as in the first model: the higher is the subcategory, the lower will be the employment rate. In this case the only difference is that the coefficients of the first model have larger amplitude between the Size1: 2.35 and Size6: -3.5 then the

second model: 1.7 and -1.2, respectively. This means that smaller firms have a higher employment rate than the bigger ones, but the difference is not as high as in the investment level. In this model we can also see that firms that have been in the market for less than 6 year, on average, hire 58.7% more employees than the other firms, cp. Thus, from these last two variables we can conclude that young and small firms in Portugal have a higher rate of investment and employment that the older and bigger companies.

The last variable indicates that, on average, the employment rate of Portuguese companies in the first period is 9.5% lower than in the second period, keeping everything else constant. It also shows that the overall behavior of the employment is negative. Since the unemployment rate in Portugal decreased from 10.3%, in 2010 to only 7% in 2018, it looks contradictory with the results, according to Pordata. However, if we look at the active population in Portugal in the same period of time, the numbers show that there was a reduction of 4.68% in the active population. Since the unemployment rate only decreased 3.3%, that reduction can be thank to the decrease on the active population in Portugal, and not a real decrease on the unemployment. Thus, the overall employment of the Portuguese firms can have been negative in those years, as the model shows.

To verify the significance of the second model was used the global significance test. To compile this test, was used the test statistic F. In this test the null hypothesis (H_0) is:

H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = 0$, and

H_1: H_0 is not verified.

In this test H_0 is rejected if $F_{obs} > F_{crit.}$

$$F_{obs} = \frac{ESS/(K-1)}{RSS/(n-k)} = \frac{\frac{R^2}{(k-1)}}{\frac{(1-R^2)}{(n-k)}} \sim F_{crit} = F_{k-1,n-k,\alpha}$$

Because F_{obs} = 25945.81 and F_{crit} = 1.83 (with α = 5%), the $F_{obs} > F_{crit}$, thus H_0 is rejected. This means the second model is also globally significant.

The R^2 in this model is close to 49%, which is higher than the previous one and means that this model explains better the dependent variable, in this case, employment rate. It can also be seen that Root Mean Square Error (RMSE) is already considerably lower, which means that the standard deviation of residuals is lower and therefore may have less heteroscedasticity than the previous model. Thus, the

same test was performed to analyze the existence of this problem. However this model also revealed a considerable level of heteroscedasticity.

Regarding the possibility of multicollinearity, was also calculated the VIF of the model. However, as the mean VIF was 1.72, we considered there is no major multicollinearity in the model.

The last model tries to explain multi-factor productivity through the same variables as the other models and the effect that zombie firms have on non-zombie companies' MFP.

As in other regressions, the most important coefficient to consider is the one of the interaction, whose value in this regression is positive. This indicates that higher the percentage of zombie capital in the industry, the higher will be the MFP of healthy companies. In other words, when the share of capital sunk in zombie firms increases by one percentage point, the MFP of healthy companies in that sector increases, on average, by 4%, keeping everything else constant.

Regarding the first variable we can take more consistent conclusion as indicates that, on average, the non-zombie firms have 147.5% higher MFP then the zombie ones when there is no capital sunk in zombie fimrs, cp. This means that the higher the share of zombie capital in the industry, the greater will be the difference (gap) in productivity between the most dynamic companies and the others (laggards), Gouveia and Osterhold (2018), which is in line with the predictions of the model in Caballero et al. (2008) and with the results in McGowan et al. (2017). This result is important because as the MFP gap grows, the greater will be the competition in that industry, and the harder it will be for new companies to enter in the market and substitute the zombie ones. This is one of the obstacles to market entry caused by zombie companies' market congestion.

On the *Size* variable the coefficient indicator is negative on the first subcategories and positive on the last three of them. This means that small companies have smaller MFP then bigger ones. For example, companies in the second subcategory have, on average, an 82.6% lower MFP level than the firms of third subcategory, *cp*. This can be explained because the larger the company is, the greater the economy of scale and the greater is the know-how due to more accumulated experience of the workers.

The *Young* variable is associated with lower MFP levels, as the coefficient sign is negative. Thus we can say that, on average, the Portuguese firms under 6 years have a 36% lower MFP level than the rest of the companies, keeping everything else constant.

The last variable indicates there was a general growth of the MFP of the Portuguese firms during the analyzed years. On average, the MFP grew almost 7.7% in the last 3 years, compared to the previous period, *cp.*

However, this model has the lowest value of R^2 among the three models (11.4%), which means there are much more variables that could explain what influences the MFP level (like the technological level of the capital, the workers education, etc.).

Regarding its global significance, this model was also submitted to the test statistic F, where the null hypothesis was rejected, since the F_{obs} = 10533.1 and F_{crit} = 1.83 (with α = 5%) which implies that $F_{obs} > F_{crit}$. In this model were also applied the consistency tests of to the previous regressions, revealing that the OLS3 model also has problems related to heteroscedasticity, and a higher VIF level than the other models, namely 1.92. Although this value does not show a large degree of collinearity at a general level, individually the first two variables, *Z* and *nonZ*, have the two highest levels of collinearity: 3.46 and 3.45, respectively, which increase the mean VIF of the regression.

That said, a joint significance test of these variables was executed to verify their significance at statistical level, where the null hypothesis implies that both coefficients are equal to zero:

H_0: $\beta_1 = \beta_2 = 0$, and

H_1: At least one $\beta_j \neq 0$, where j = 1,2

In this test H_0 is rejected if $F_{obs} > F_{crit.}$

$$F_{obs} = \frac{\frac{R^2_{NR} - R^2_R}{m}}{\frac{(1 - R^2_{NR})}{(n-k)}} \sim F_{crit} = F_{m,n-k,\alpha}$$

Because F_{obs} = 1575.6 and F_{crit} = 1.83 (with α = 5%), the $F_{obs} > F_{crit}$, thus H_0 is rejected, which means the tested variables are relevant to determine the MFP behaviour. Besides that, they are also statistically significant because the individual significance test has a P-value lower than 1%, as we can see on table 2.

Besides heteroscedasticity problems, OLS models often have endogeneity problems, i.e. a situation where Cov (X, u) ≠ 0. In this context, the regressions presented in the OLS models may not reflect the causal effect of zombie companies and the other variables presented in the different parameters of the

Portuguese economy (dependent variables). This is because the coefficients of the explanatory variables capture some of the effects that otherwise would be attributed to missing variables.

For example, if we omit from the OLS3 model the technological level of capital (more sophisticated software or computer programs), and if this variable correlates with some explanatory variable (zombie capital) and the MFP, the estimates obtained by OLS will be biased. In this case, the error results because the estimation ignores the fact that companies with a higher technology level present a higher MFP than companies with a lower technology level, for the same level of capital. Thus what negatively affects the MFP may be, for example, a low technological level of capital, and not necessarily zombie capital. Similarly, what may increase the MFP gap between zombie companies and other companies may be due to the fact that the first one have a lower technology level, or any other omitted variable that makes them less efficient. Thus, the existence of endogeneity in a regression can be understood as a case of omission of relevant explanatory variables, Verbeek, 2012 and Wooldridge, 2010.

5.2. Fixed Effects Models

As seen in section 4.2, panel data combines cross-section information with time series data, allowing to track a particular company over time. Consequently, the different observations for the same company are not independent, which justifies the use of models that fit the specificities of the variance and covariance matrix, such as the Fixed Effects Model (FE).

These models only consider variability within the company itself (within), ignoring variation among different companies (between). Thus, one of the solutions consists precisely of the first difference model, however, this procedure is less efficient as it involves the loss of one observation. An alternative solution is to subtract each variable from its mean within each observation unit. Thus, the FE model (table 5 attached) was performed to solve the endogeneity problems.

However, despite the correction of some endogeneity problems, the models continued to present heteroscedasticity. Thus, a new set of estimates was added where robust standard errors were clustered at the industry level to estimate efficient coefficients. Table 4 presents the results of the robust estimates.

Table 4 – Zombie Capital and non-Zombie Firm Performance: FE Robust Models

	FE 1 Robust	FE 2 Robust	FE 3 Robust
VARIABLES	Dln(I/K)	Dln Emp	MFP
$nonZ_{it}$	0.266***	-0.0660***	1.554***
	(0.0245)	(0.0246)	(0.0393)
$nonZ_{it}$ x Z_{st}	0.00123	-0.00351**	0.0109***
	(0.00159)	(0.00148)	(0.00250)
$Size_{it} = 1$	0.416***	0.319***	-0.590***
	(0.0199)	(0.0139)	(0.0321)
$Size_{it} = 2$	0.194***	0.0734***	-0.304***
	(0.0164)	(0.0116)	(0.0283)
$Size_{it} = 4$	-0.136***	0.0933***	0.337***
	(0.0287)	(0.0210)	(0.0650)
$Size_{it} = 5$	-0.349***	0.173***	0.423**
	(0.0497)	(0.0391)	(0.181)
$Size_{it} = 6$	-0.434***	0.446***	0.789**
	(0.0870)	(0.0746)	(0.352)
$Young_{it}$	0.395***	0.336***	-0.0777***
	(0.00767)	(0.00840)	(0.00648)
$Period_t = 1$	0.0887***	0.0210***	-0.0141***
	(0.00537)	(0.00628)	(0.00382)
$Period_t = 3$	-0.231***	-0.269***	0.154***
	(0.00409)	(0.00445)	(0.00336)
Number of Observations	910,223	298,331	900,625
R^2 overall	0.2019	0.2041	0.0594
ρ	0.82	0.67	0.71
Number of Firms	279,133	135,992	227,017

Note: *Z* refers to the share of industry capital sunk in zombie firms, defined as firms aged ≥10 years and with an interest coverage ratio lower than 1 over three consecutive years. *Dln (I/K)* refers to the investment ratio, i.e. the ln difference of the real capital stock; *Dln Emp* refers to the natural logarithm of change in employment and *Ln MFP* is the level of multi-factor productivity based on the Solow-residual. Standard errors in parentheses: *** denotes statistical significance at the 1% level, ** significance at the 5% level, * significance at the 10% level. In parentheses are reported the robust standard-error.

Source: Authors' calculations.

The results obtained in the Robust FE models indicate that the fixed effects (ρ) in each model account for 82%, 67% and 71% of the total variance of the composite standard error, respectively. Thus, the results suggest that a substantial part of the variance of the outcome is due to unobserved heterogeneity. The standard error composite value is calculated as follows:

$$\rho = \frac{(\sigma_u)^2}{(\sigma_u)^2 + (\sigma_e)^2}$$

Where σ_u corresponds to the standard error of the individual effect, σ_e to the standard error of the error term and (σ_u+σ_e) to composite standard error.

Given this, it is important to begin by pointing out some of the major changes and differences in these latter models from the OLS models. Thus, in general, the coefficients of almost all variables decreased in the new models. This was expected since the endogeneity part of the explanatory variables was removed, which in the OLS models was attributed to explain the variation of the dependent variable. The number of observations remained the same but the R^2 decreased in all models. In the second model is where this difference is most notable (from 49% to almost 20%).

That said, in the FE1 robust model the most significant change is in the main variable, since controlling for unobserved heterogeneity it has a positive value. Although this drastic change, it is not statistically significant, which means the result cannot be trust. However, is understandable that zombie firms have no major effect in the investment of Portuguese firms since they don't rely much on external financing funds, due to the Portuguese banks lack of technical skills to evaluate good projects, Alexandre et al. (2017).

Another major change in this model is related with the *Period* variable, whose signs changed from positive to negative when fixed effects are included. Thus, the new result indicates that on the first period the Portuguese companies invested, on average, 8.8% more than the following period, keeping everything else constant. This may happened because the second period includes 2013, which was the peak of the crisis in Portugal, so the firms invested less because of the instability of the financial system.

Regarding the rest of the variables, although they continue statistically relevant at 1% level and with the same signal, the coefficients dropped significantly.

In the second model of table 4, the interaction variable became statistically significant at a 5% level because of controlled unobserved heterogeneity. This indicates that zombie capital continues to negatively influence the employment of healthy companies, but with the fixed effects included it has more impact that had on the OLS2 model. Thus, on average, when the share of capital sunk in zombie firms increases by one percentage point, the employment rate of healthy companies in that sector decreases by 0.35%, *ceteris paribus*.

In the same model, it was noted that the *nonZ* continues negative and with a similar coefficient value with the fixed effects included. Thus, controlling for unobserved heterogeneity the variable remains the same.

In the FE2 robust model the third subcategory companies employed fewer workers than the others and the sixth subcategory had the biggest employment growth in the analyzed years. Thus, the companies with more than 250 workers, on average, employed 44.7% more than the third subcategory firms, keeping everything else constant.

The *Young* dummy maintained the same behavior and statistical significance but the coefficient had a minor decrease.

Regarding the time variable *Period*, we can see that in fact the employment slightly increased in the first period compared with the period of the peak of the crisis and in the last years there was a substantial drop on the employment growth. On the last period, Portuguese firms, on average, employed 27% less workers than in the second period. That may be one of the reasons for the emigration of the active population and the slow recovery of the Portuguese GDP.

The last model presents the smallest differences, since, for example, the first variable remained almost equal when the fixed effects were included, while the interaction variable remains statistically significant and positive, but slightly decreasing the coefficient value. In fact, the biggest difference in the third model is that the interaction variable lost a considerable coefficient value.

The MFP gap between companies with more workers and fewer workers has narrowed as companies with more than 250 workers still have an average MFP level 79% higher than companies in the third subcategory, *cp*, while in the OLS model it was 312% higher. This result is interesting, as shows that controlling for unobserved heterogeneity the small companies are not that inefficient. Note that *size5* and *size6* lost some statistical significance, namely at 5% level.

Newer companies still have a lower MFP than older ones, namely 7.8%, keeping everything else constant, but the difference is lower than in the OLS model: 36%.

Regarding the interpretation of the *Period* variable, the coefficient of the period three doubled with the fixed effects. That means the MFP of the Portuguese firms increased, on average, 15.4% in the last three years analyzed, when compared with the period of the peak of the crisis. As in the first three year the firms MFP was lower than the third period it shows that the efficiency of the Portuguese firms had a positive evolution in the nine years analyzed, while the number of zombie companies has steadily declined.

6. Conclusions

As we can see from all models, zombie firms (or rather the percentage of sunken capital in zombie firms in the industry) have a negative effect on the employability. However, this negative effect may have had a double negative effect specifically on the Portuguese economy: i) the zombie firms in Portugal "imprisoned" the workers and the unemployment rate in the country bursted from 7.5% in 2008 to 16% in 2013 (according to Pordata); ii) as Portugal has a long history of emigration, the active population had no other choice than emigrate and the unemployment rate dropped as fast as it increased. When active population leaves a country in such big scale the economy and GDP recovery is very slow because the production, consume and governmental tax revenues drop and the social and health system get overwhelmed because of the lack of workforce.

The models also conclude that the investment rate of the Portuguese healthy firms is not negatively influenced by the zombie capital, however, that may be due the considerably low percentage of zombie firms in this database. It also shows that healthy firms had a relatively large investment, mainly during the first period analyzed. This can be explained due to the decrease of the interest rate by the Central Bank during the crisis (which made the investment cheaper and more attracting) and because of the most dynamic firms don't rely much on external financing funds, due to the Portuguese banks lack of technical skills to evaluate good projects, Alexandre et al. (2017).

Thus, these results demonstrate two important things. First, zombie companies in this context represent a congestion of market resources (notably labor and capital), harming the other companies in the economy at both levels. And secondly, the larger the zombie share in a given industry, the greater will be the difference (gap) in productivity between the most dynamic companies and the laggards, Gouveia and Osterhold (2018). This result is important because as the MFP gap grows, the greater will be the competition in that industry, and the harder it will be for new companies to enter in the market and substitute the zombie ones. This is one of the obstacles to market entry caused by zombie companies' market congestion and may be related to a slower recovery of the economy after the financial crisis.

We can also conclude that: keeping zombie companies alive under the pretext to not increasing unemployment (and consequently a greater recession in the last financial crisis) is not consistent, because keeping these companies alive decreases the employment growth of healthy companies in the market, reaching the same result, but by a slower rate. Thus, the direct opportunity cost of keeping

alive the zombie firms is the entry into the economy of new and potentially more efficient companies. It also leads to the emigration of the most young and skilled population Pereira (2019).

On the other hand, due to some negative aspects of the database pointed out in section 4.1, it was impossible to calculate the risk-free interest rate, which prevented zombie companies from being identified as intended, hence the small percentage of zombie companies found.

Another problem related to Amadeus is the permanent elimination of bankrupted companies from the database, which not only influences the percentage of zombie firms found, but may also have influenced the weight that these companies had in the Portuguese economy and the slow recovery. For example, the construction sector is one of the industries in Portugal with most zombie firms, Barros et al. (2017), while in this study its percentage is close to the national average. Thus, the database does not perfectly represent the reality of the Portuguese economy, but rather in a distorted way.

One of the most worrying aspects of this investigation was the discovery of a huge percentage of zombie companies in the public sector, which has been steadily increasing over the past four years, which may start another public sector crisis.

Regarding the consistency of the empirical models, the latest results point to a substantial degree of unobserved heterogeneity and key variables had a relatively low statistically significance in the FE robust models, so further studies about zombie firms' impact in the Portuguese economy are needed to better understand their role.

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Appendix

Table 5 – Zombie Capital and non-Zombie Firm Performance: FE Models

	FE 1	FE 2	FE 3
VARIABLES	Dln(I/K)	Dln Emp	MFP
nonZ_{it}	0.266***	-0.0660**	1.554***
	(0.0340)	(0.0286)	(0.0503)
nonZ_{it} x Z_{st}	0.00123	-0.00351**	0.0109*
	(0.00221)	(0.00127)	(0.00567)
$\text{Size}_{it} = 1$	0.416***	0.319***	-0.590***
	(0.0727)	(0.0308)	(0.0347)
$\text{Size}_{it} = 2$	0.194***	0.0734***	-0.304***
	(0.0436)	(0.0192)	(0.0221)
$\text{Size}_{it} = 4$	-0.136***	0.0933***	0.337***
	(0.0239)	(0.0284)	(0.0309)
$\text{Size}_{it} = 5$	-0.349***	0.173*	0.423**
	(0.0593)	(0.0913)	(0.193)
$\text{Size}_{it} = 6$	-0.434***	0.446***	0.789*
	(0.0916)	(0.119)	(0.440)
Young_{it}	0.395***	0.336***	-0.0777***
	(0.0177)	(0.0210)	(0.0108)
$\text{Period}_t = 1$	0.0887***	0.0210	-0.0141
	(0.0277)	(0.0239)	(0.0403)
$\text{Period}_t = 3$	-0.231***	-0.269***	0.154***
	(0.0215)	(0.0126)	(0.0226)
Number of Observations	910,223	298,331	900,625
R^2 overall	0.2019	0.2041	0.0594
ρ	0.82	0.67	0.71
Number of Firms	279,133	135,992	227,017

Note: *Z* refers to the share of industry capital sunk in zombie firms, defined as firms aged ≥10 years and with an interest coverage ratio lower than 1 over three consecutive years. *Dln (I/K)* refers to the investment ratio, i.e. the ln difference of the real capital stock; *Dln Emp* refers to the natural logarithm of change in employment and *Ln MFP* is the level of multi-factor productivity based on the Solow-residual. Standard errors in parentheses: *** denotes statistical significance at the 1% level, ** significance at the 5% level, * significance at the 10% level. In parentheses are reported the robust standard-error.

Source: Authors' calculations.

Table 6 – 5% Critical Values of the *F* Distribution

Denominator Degrees of Freedom	Numerator Degrees of Freedom									
	1	2	3	4	5	6	7	8	9	10
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99
90	3.95	3.10	2.71	2.47	2.32	2.20	2.11	2.04	1.99	1.94
120	3.92	3.07	2.68	2.45	2.29	2.17	2.09	2.02	1.96	1.91
∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88	1.83

Note: The 5% critical value for numerator *df* = 4 and large denominator *df* (∞) is 2.37.

Source: This table was generated using the Stata® function invfprob.

Table 7 – Critical Values of the *t* Distribution

Significance Level						
1-Tailed:		0.10	0.05	0.025	0.01	0.005
2-Tailed:		0.20	0.10	0.05	0.02	0.01
Degrees of Freedom	1	3.078	6.314	12.706	31.821	63.657
	2	1.886	2.920	4.303	6.965	9.925
	3	1.638	2.353	3.182	4.541	5.841
	4	1.533	2.132	2.776	3.747	4.604
	5	1.476	2.015	2.571	3.365	4.032
	6	1.440	1.943	2.447	3.143	3.707
	7	1.415	1.895	2.365	2.998	3.499
	8	1.397	1.860	2.306	2.896	3.355
	9	1.383	1.833	2.262	2.821	3.250
	10	1.372	1.812	2.228	2.764	3.169
	11	1.363	1.796	2.201	2.718	3.106
	12	1.356	1.782	2.179	2.681	3.055
	13	1.350	1.771	2.160	2.650	3.012
	14	1.345	1.761	2.145	2.624	2.977
	15	1.341	1.753	2.131	2.602	2.947
	16	1.337	1.746	2.120	2.583	2.921
	17	1.333	1.740	2.110	2.567	2.898
	18	1.330	1.734	2.101	2.552	2.878
	19	1.328	1.729	2.093	2.539	2.861
	20	1.325	1.725	2.086	2.528	2.845
	21	1.323	1.721	2.080	2.518	2.831
	22	1.321	1.717	2.074	2.508	2.819
	23	1.319	1.714	2.069	2.500	2.807
	24	1.318	1.711	2.064	2.492	2.797
	25	1.316	1.708	2.060	2.485	2.787
	26	1.315	1.706	2.056	2.479	2.779
	27	1.314	1.703	2.052	2.473	2.771
	28	1.313	1.701	2.048	2.467	2.763
	29	1.311	1.699	2.045	2.462	2.756
	30	1.310	1.697	2.042	2.457	2.750
	40	1.303	1.684	2.021	2.423	2.704
	60	1.296	1.671	2.000	2.390	2.660
	90	1.291	1.662	1.987	2.368	2.632
	120	1.289	1.658	1.980	2.358	2.617
	∞	1.282	1.645	1.960	2.326	2.576

Note: The 1% critical value for a one-tailed test with 25 *df* is 2.485. The 5% critical for a two-tailed test with large (> 120) *df* is 1.96.

Source: This table was generated using the Stata® function invt.